OSIRIS-REx Archive Overview
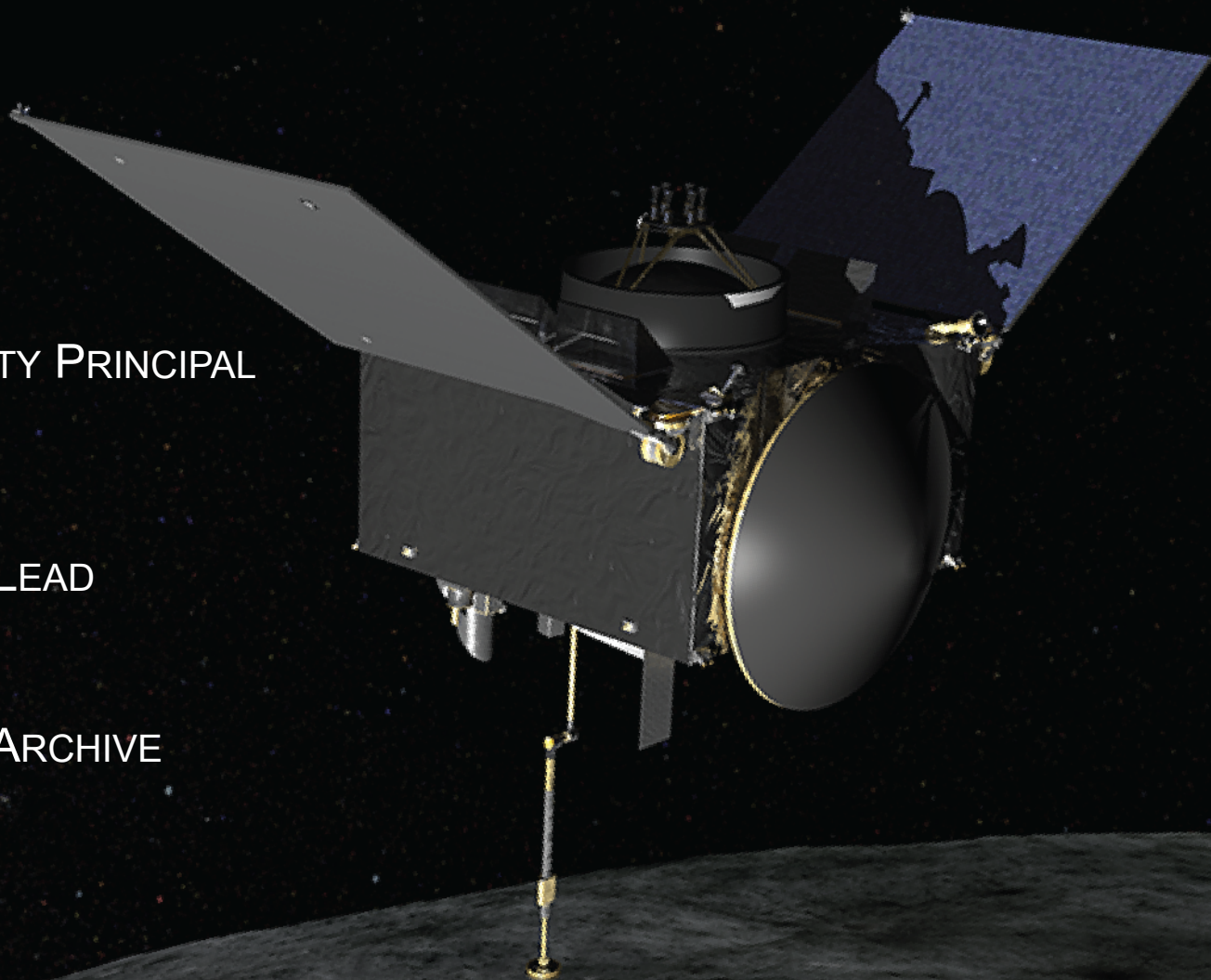
Ed Beshore-
OSIRIS-REx Deputy Principal Investigator

Kate Crombie –
OSIRIS-REx PDS Lead

Carol Neese –
OSIRIS-REx PDS Archive Manager

MISSION OBJECTIVES

- **O**rigins
  - Return and analyze a sample of pristine carbonaceous asteroid regolith in an amount sufficient to study the nature, history, and distribution of its constituent minerals and organic material

- **S**pectral **I**nterpretation
  - Characterize the integrated global properties of a primitive carbonaceous asteroid to allow for direct comparison with ground-based telescopic data of the entire asteroid population

- **R**esource **I**dentification
  - Map the global properties, chemistry, and mineralogy of a primitive carbonaceous asteroid to characterize its geologic and dynamic history and provide context for the returned samples

- **S**ecurity
  - Measure the Yarkovsky effect on a potentially hazardous asteroid and constrain the asteroid properties that contribute to this effect

- **R**egolith **Ex**plorer
  - Document the texture, morphology, geochemistry, and spectral properties of the regolith at the sampling site in situ at scales down to the sub-centimeter
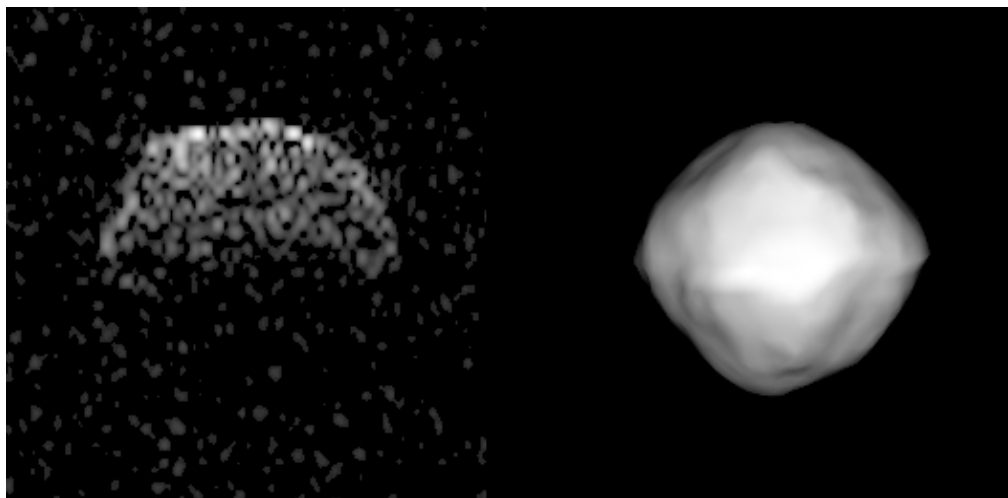
- It is primitive B-class carbonaceous asteroid, with a spectral signature suggesting a **carbon- and volatile-rich surface**

- Its **size (500-m), shape (spheroidal "spinning top"),** and **rotation state (4.3 hr period, 180º obliquity)** are known from extensive astronomical characterization

- All available data suggest **abundant regolith** on the surface available for sampling

- Study of this **Potentially Hazardous Asteroid** is strategically important to NASA and Congress

- These assumptions and constraints are documented and updated through our **Design Reference Asteroid** document

OVERVIEW OF THE OSIRIS-REx MISSION

- 2011 – May 25: Mission Selection
- 2013 – June 1: Mission Confirmation
- 2016 – September 3: Launch window opens
- 2018 – 2021: Bennu encounter
  - 2018 – August: Approach Phase – Astronomical properties and environment
  - 2018 – November: Survey Phase – Bulk properties, shape and spectroscopy
  - 2019 – January: Orbital Phase – Topography, gravity, and preliminary site characterization
  - 2019 – March: Recon Phase – Detailed sample-site characterization
  - 2019 – May: Rehearsal Phase – Rehearse sampling maneuvers
  - 2019 – July: **Collect at least 60 grams** of asteroid regolith
  - 2021 – March: Leave vicinity of asteroid
- 2023 – September 24: **Return Sample to Earth**
- 2025 – September 30: End of Sample Analysis and End of Mission

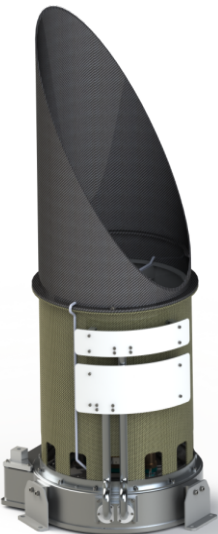# Science Requirements are Fulfilled by the Instrument Capabilities

OCAMS (UA)
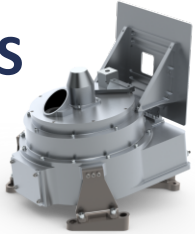
SamCam images the sample site, documents sample acquisition, and images TAGSAM to evaluate sampling success

MapCam provides landmark-tracking OpNav, performs filter photometry, maps the surface, and images the sample site
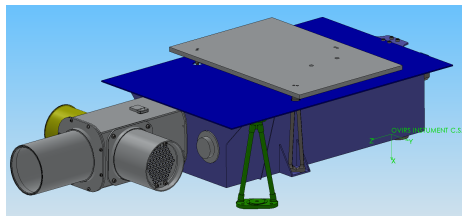
PolyCam acquires Bennu from >500K-km range, performs star-field OpNav, and performs high-resolution imaging of the surface
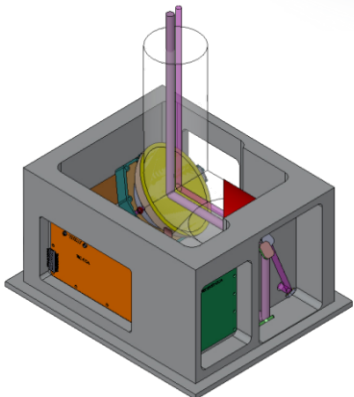
OLA (CSA) provides ranging data out to 7 km and maps the asteroid shape and surface topography

SCIENCE REQUIREMENTS ARE FULFILLED BY THE INSTRUMENT CAPABILITIES

OVIRS (GSFC) maps the reflectance albedo and spectral properties from 0.4 – 4.3 μm

OTES (ASU) maps the thermal flux and spectral properties from 4 – 50 μm
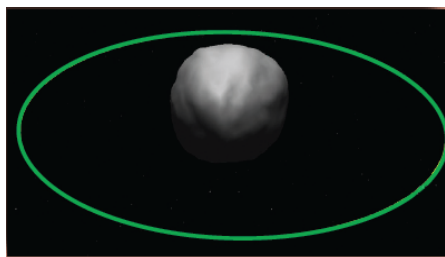
Radio Science (CU) reveals the mass, gravity field, internal structure, and surface acceleration distribution

REXIS (MIT) is a Student Collaboration Experiment that trains the next generation of scientists and engineers and maps the elemental abundances of the asteroid surface

OSIRIS-REx Observation Approach

- With few exceptions, all of the data generated during proximity operations assist with site selection
  - Some data only indirectly assist, e.g. generating surface landmarks for navigation

- OSIRIS-REx Observation Plan is captured in the Design Reference Mission (DRM)
  - Daily plan outlining spacecraft activities

- DRM provides global coverage followed by local data
  - Early global data leads to selection of up to 12 candidate sites
  - Later data concentrates on these sites at higher resolution

SCIENCE OBSERVATION OVERVIEW

Approach — Hazard Survey, Ephemeris Updates

Prelim Survey — Initial Shape and Gravity Models

Orbital A — Transition to Landmark Tracking

Detailed Survey — Global Mapping, Initial 12 Site Selection

Orbital B — Topographic and Spectral Mapping, Refined Gravity, Down Select to 4 Sites

Recon — High Resolution Observations, Final Site Selection

Rehearsal — TAG Operational Refinement

TAG — Sample Retrieval
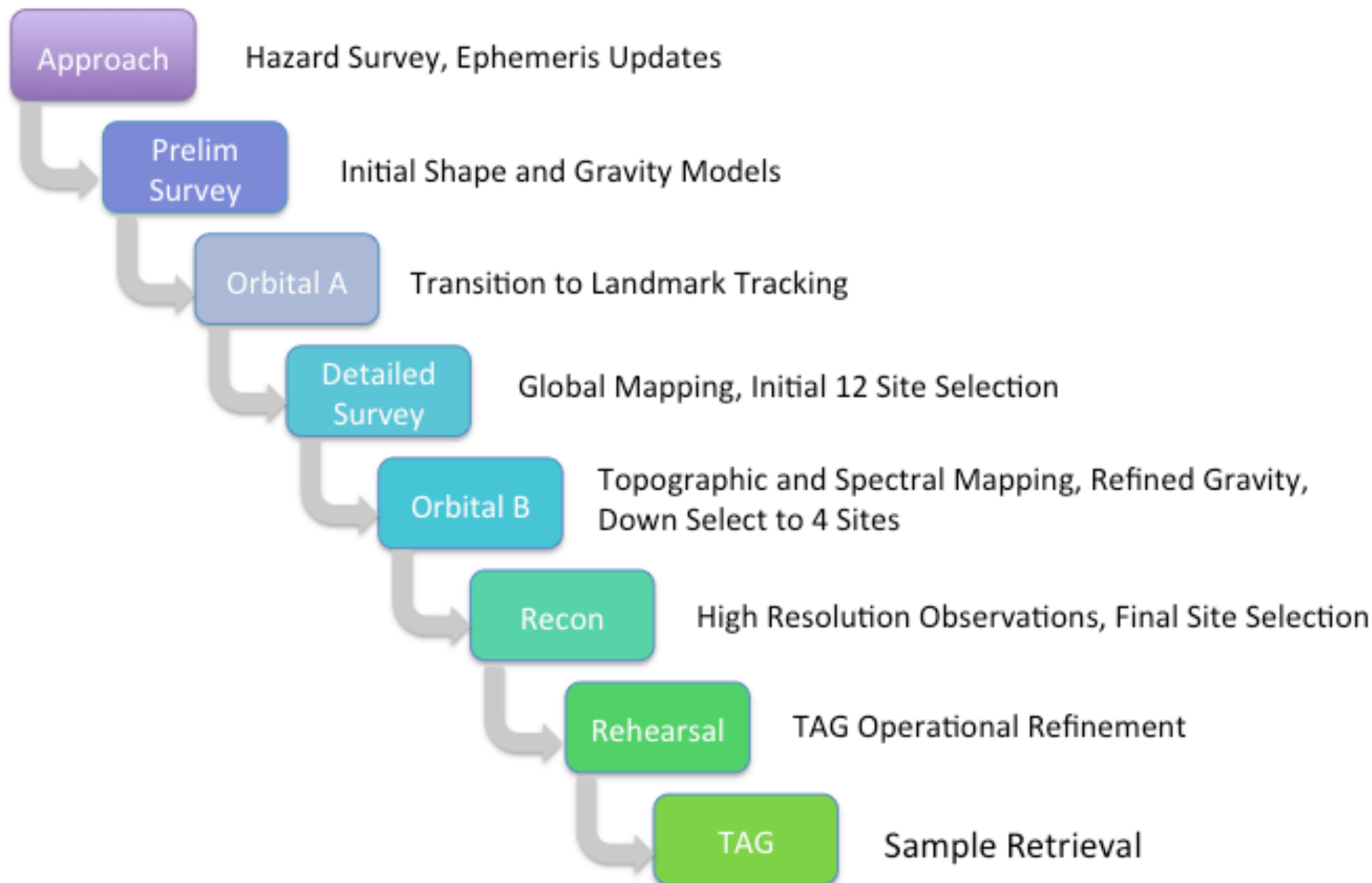
- Science Data is collected to support Sample Site Selection.

- Data Processing needs to be well understood and routine in order to meet mission timelines.

  - To support mission data processing timelines:

    - Early development of the ground data processing pipelines
      - Baseline versions of instrument data processing pipelines are being delivered to the SPOC now.
      - Higher-level processing to come together over the next year.

    - General philosophy is to use minimal set of data formats
      - OREx Science team will use same data formats as those delivered to PDS.

SPOC Functional Architecture
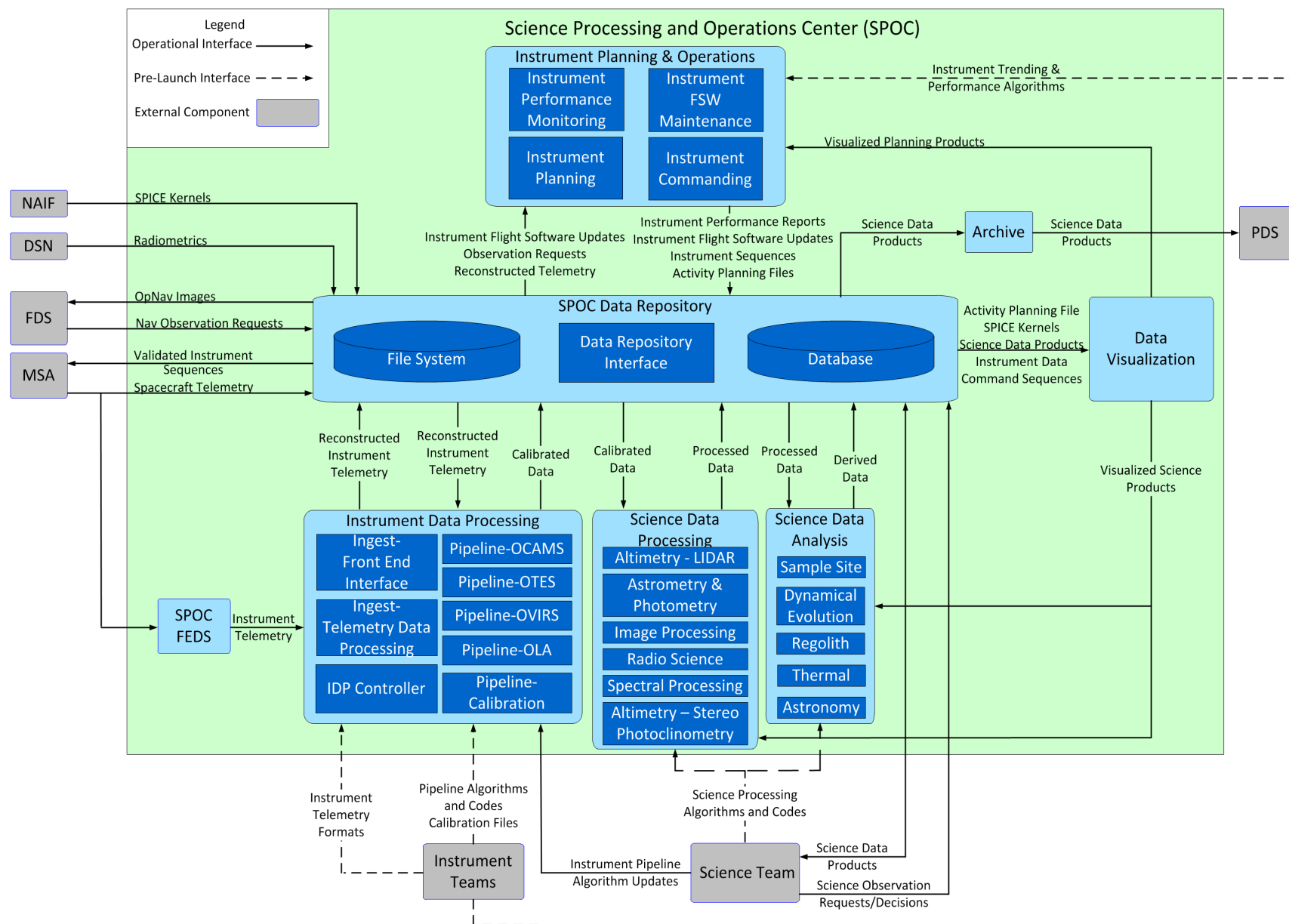
OSIRIS-REx Archive Overview

- ## OSIRIS-REx will deliver:

  - Pipeline Data Products – Instrument (OCAMS, OLA, OTES, OVIRS) Raw to Calibrated Data

  - Higher-Level Data Products – Astrometry & Photometry, Altimetry, Image Processing, Radio Science, Spectral Processing, Regolith Development, and Thermal Analysis

  - Single Delivery Products – Coordinate System, REXIS, TAGSAM, TAGCAMS and GNC LIDAR Products

  - Special Products – Ground-based Data and Sample Site Selection Data

ARCHIVE PLANNING

- Carol Neese to talk about Archive Planning and Reviews

ORGANIZATION OF ARCHIVE

- One bundle per instrument, containing both raw and calibrated data
- Each bundle covers the duration of the mission for its instrument
- Collections organized by processing level
- Several bundles for higher level products
- A bundle for SPICE
- A bundle for the mission
- etc.

Overview of Review Planning

- Review panels mostly by instrument, but combine some instruments which require similar expertise.
- A panel typically has three external reviewers.
- Three review panels for pipeline instruments, one each for OCAMS, and OLA, and a combined panel for OVIRS and OTES.
- TAGSAM and GNCL will be reviewed by the same panel as OLA.
- Separate review panels for other non-pipeline data, including REXIS, Bennu coordinate system, SPICE, RS, and higher level products.
- For continuity, keep the panel membership the same throughout the mission (to the extent possible)

REVIEW OF PIPELINE DATA

- OCAMS, OLA, OTES, and OVIRS will have configuration controlled data pipelines.
- Pipeline data are reviewed in a series of review stages.
- Pipeline is first reviewed pre-launch, with test data. Liens resolution produces a good approximation to the final pipeline.
- Output of the pipeline is again reviewed with real in-flight data from EGA. Liens resolution produces a pipeline capable of producing directly archivable data. But...
- Configuration control board monitors any changes to the pipeline or to circumstances, calling for additional review when needed.
- Non-pipeline data (REXIS, TAGSAM, RS, SPICE, etc.) are reviewed separately after full data set is delivered.

SEQUENCE OF PEER REVIEWS

- 4 Product design reviews, 2014 and 2015
- 3 Pipeline reviews, 2016
- 3 In-flight pipeline data reviews using EGA data, 2018
- Bennu coordinate system review, 2019
- TAGSAM and GNCL reviews, 2020
- Higher-level products review, 2022
- Plus REXIS, RS, SPICE, and Special Products, TBD.

- Early product design reviews critical for pipeline development. Non-pipeline product design not quite as time critical.

- OCAMS raw and calibrated, Aug. 2014

- OLA raw and calibrated, Aug. 2014

- OTES and OVIRS raw and calibrated, Aug. 2014

- These 3 reviews of pipeline products in Aug. 2014 will happen in parallel.

- Non-pipeline products: REXIS raw, TAGSAM, GNCL, etc. TBD, but hopefully 2014 or 2015.

- Higher-level products, mid-2015

PLANS FOR DATA DELIVERIES

- Raw/Uncalibrated Pipeline data – First delivery at encounter + 6mo, then every 3 months

- Calibrated Pipeline data – First delivery at encounter + 9m, then every 3 months

- TAGSAM/GNCL – Late 2019/Early 2020

- Higher level products – 2022

- Some revisions expected, final delivery schedule to be confirmed June 2015

ARCHIVE STATUS

- ## Mission – PDS Memorandum of Understanding
  - Signed – March 2012

- ## SPOC – PDS Interface Control Document
  - Signed – November 2013

- ## Science Data Management Plan
  - Mature draft available under revision.
  - Signed by MOR – June 2015

- ## Archive Documentation
  - Documentation to be developed over the next year.
  - Signed versions of SISs following PDS Pipeline Peer Reviews.
    - Pipeline SIS are currently in draft format.
    - Archive CONTEXT documents in development
      - Additional documentation on Archive Documentation preparation would be helpful.

SPECIAL PRODUCT DEVELOPMENT

- ## OSIRIS-REx will develop two Special Products
  - Ground-based Observations
    - Catalog of observations of Bennu made by OSIRIS-REx Science Team Members.
      - Observations not archived elsewhere
      - Pointers(references) to observations held in other NASA archives.
    - This data collection is notional at the moment
      - Defined over the next year.

  - Sample Site Selection Data
    - Collection of the data products used in the Sample Site Selection.
      - These are not "perfect" archive products, and should be thought of as an historical document.
      - Special Product will include narrative of decision process and "Briefing Sheets" used to document data product status and/or issues.
    - This data collection is notional at the moment
      - Defined over the next year.

SINGLE DELIVERY PRODUCT DEVELOPMENT

- Single Delivery Products are data products that are produced during a specific portion of the mission (generally TAG).
  - REXIS - Student Experiment X-ray Spectrometer
    - L0 Science and Housekeeping data. (Binary Tables)
    - Data originally planned to be collected during a single mission phase (global coverage)
      - May move to pipeline delivery schedule depending on final observation plan
  - Flight System Instruments -
  - TAGSAM –
    - Single delivery data product that records converted engineer values from the TAGSAM assembly.
    - Details of this product are still under negotiation.
  - GNC LIDAR -
    - Single delivery data product similar in format to OLA data that records LIDAR measurements during the TAG event.
    - Details of this product are still under negotiation.
  - TAGCAMS (NavCam and StowCam)
    - Single delivery image data products similar in format to OCAMS images
    - Details are still under negotiation

HIGHER-LEVEL DATA PRODUCTS

Collection	Data Products
Altimery	
	Global and Site Specific Topographic Maps
	Shape Model
	Coordinate System
	Pole Location, Wobble and Rotation Period
Astrometry & Photometry	
	Asteroid Light Curves
	Asteroid Phase Functions
	Satellite Images and Proof of Existance
Image Processing	
	Global 21-cm Mosaics
	Global and Site Specific b-v index, v-x index, and 0.7-µm absorption color ratio maps
	Global and Site Specific PSF Maps
	Stereo Images of Asteroid Surface
Radio Science	
	Natural Satellite Ephemeris
	Global Gravity Field Map
	Spherical Harmonic Coefficients
	Global Slope Map
	Asteroid Mass Model
Spectral Processing	
	Global and Site Specific Mineral and Chemical Maps
	Global Bond Albedo Map
Thermal	
	Global and Site Specific Thermal Inertia
	Global and Site Specific Temperature Maps

- ## Osiris-Rex Science Team Working Groups direct development of Higher-Level Data Products

  - ### List of Higher-Level Products to be delivered to be reviewed
    - Possible addition of products from the Spectral Analysis Working Group

  - ### Baseline Data Formats are due for internal review the end of July.

  - ### Many products are maps
    - Science team has initial agreement on metadata to be carried with all maps as well as standard projection.
    - Interchange format is yet to be agreed upon.

- OTES Data Products
  - RAW(tlm) - Instrument telemetry records in time order. (Binary Table)
    - Prototype labels are in development

  - RAW(look) - Instrument telemetry+interferogram records in time order. (Binary Table)
    - Prototype labels are in development

  - Geo files - Each Raw(look) has an associated Geo (geometry) file that is a FITS format Binary Table.
    - Prototype labels are in development

  - Calibrated Spectra - An OTES calibrated radiance file will be composed of two time ordered tables of homogenous records each, one containing the calibrated radiance, and the second containing calibration records (voltage spectrum) used in the calibration process. (Binary Table)
    - Prototype labels are in development

PIPELINE PRODUCT DEVELOPMENT - OLA

- OLA Raw (L0) Science Data – These data are reconstructed from instrument telemetry and include time of observation, time of flight, intensity and instrument positional data in digital numbers (DN).
  - Prototype Labels are completed

- OLA Raw State (L0) of Health Data - These data are reconstructed from instrument telemetry and include instrument rates, status and temperatures in DN.
  - Prototype Labels are completed

- OLA Uncalibrated (L1) Science Data – Identical in format to the raw data, with engineering conversions applied resulting in data in physical units.
  - Prototype Labels are in development

- OLA Uncalibrated (L1) State of Health Data - Identical in format to the raw data, with engineering conversions applied resulting in data in physical units.
  - Prototype Labels are in development

- OLA Calibrated Data (L2) – These data are a table of time, range, scan type flag, and Bennu surface position of the observation.
  - Prototype Labels are in development

PIPELINE PRODUCT DEVELOPMENT - OVIRS

Very recent update (March 31, 2014) – Still working with instrument team to rectify with initial pan.

- OVIRS Raw Science Data (Level-0 data) – raw instrument science data. Each level-0 file will be processed as a unit through the pipeline. Level-0 files are normally segmented by "sequence" which can include both calibration and target data. Stored in FITS file with the format determined by instrument Data Processing Mode.

- GeoGen data – geometric information calculated by the SPOC. This provides raw pointing, and target geometry information. FITS file format

- OVIRS Housekeeping Data – housekeeping data stored in the SPOC database. A selection of HK fields are queried for during the data processing pipeline. The relevant HK values are stored in a CSV file along with the processed science data.

- OVIRS Pre-Calibrated Science Data (Level-1 data) – intermediate file created by the processing pipeline during the calibration process. This is basically the Level-0 data reformatted to match a supported ROI configuration that has associated calibration files, plus some additional frame-by-frame information determined by the HK and GeoGen files. Stored in a FITS file in the "Packed" format.

- OVIRS Calibrated Science Data (Level-2 data) – instrument data that has been calibrated to radiance units. Every pixel for a specific wavelength in a particular filter segment is averaged to produce a single spectral measurement. Stored in a FITS file in the "Reduced" format.

- OVIRS Calibrated Spectra Data – Final spectra data produced by the processing pipeline. Each spectral measurement is resample to achieve the required SNR. Stored in a FITS file in the "Spectrum" format.

PIPELINE PRODUCT DEVELOPMENT - OCAMS

- Very Recent Updates (April 4, 2014)
  - Product either FITS or Binary Table

    Raw –
    - Housekeeping Data (Binary Table)
    - Exposure Parameters (Binary Table)
    - Raw Image (FITS File with extensions)

    Uncalibrated
    - Housekeeping Data (Binary Table)
    - GeoFile (FITS)
    - Uncalibrated Image (FITS)
    - Cosmetically Corrected Image (FITS)

    Calibrated
    - Radiometrically Calibrated Image (FITS)

- How do we deal with Geometric Information?
  - Geo Files are very detailed geometric information, but there are summary geometric fields that should appear in the PDS4 Labels

- How do we deal with instrument or observation specific metadata recorded in the FITS header that has no obvious place in the PDS4 label?